[Editorial] Low carbon China: emerging phenomena and implications for innovation governance - introduction to the special section of environmental innovation and societal transitions

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Low Carbon China: Emerging Phenomena and Implications for Innovation Governance - Introduction to the Special Section of Environmental Innovation and Societal Transitions

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1. Introduction

This special section of 'Environmental Innovation and Societal Transitions' investigates emerging phenomena associated with low carbon transitions in contemporary China. It looks at supply and demand side dynamics, the changing role of citizens and a range of policy approaches characteristic of the Chinese context. The papers draw on diverse methods and frameworks, considering various sectors – such as energy, mobility, food and agriculture – to understand and explain these phenomena and to derive implications for innovation and transition governance.

The genesis of the collection in this special section of EIST dates back to a workshop hosted by Tsinghua University School of Public Policy and Management in March 2010 (Ely 2010), which initiated many of the conversations from which the research and resultant papers included here derive. A key contributor to this workshop and its conception was Professor Geoff Oldham, an internationally renowned scholar with fifty years of experience in Chinese science and technology policy (Oldham 2014). We have all benefitted greatly from his support and mentorship over the years, and the editors would like to dedicate this special section to his memory.

As the world's largest carbon emitter and its largest energy consumer (Zhang et al. 2017), the People's Republic of China is central to achieving substantial reductions globally (Urban 2014). With the retreat of the USA, China is increasingly adopting a leadership role in driving the global low carbon transition (Geall 2017). At the domestic level, there are several political drivers for such a transition: the government recognises the extent to which climate change presents significant challenges to the country. China is home to around 20 per cent of the world's population, yet has only about five to seven per cent of the global freshwater resources and less than 10 per cent of the world's arable land. Severe water shortages, further deterioration of aquatic systems and more flooding disasters may emerge (Zhang et al. 2009), whilst China's mega deltas are particularly vulnerable to climate change and sea-level rise (IPCC 2007). Within urban centres, rising pressure from the growing middle class is driving policies for reduced air pollution, a co-benefit alongside reduced carbon emissions (Ramaswami et al. 2017).

However, beyond such environmental drivers for transition, the government of China recognises climate-change mitigation as an opportunity for underpinning an economic transition, namely that it spurs technology leadership(Geall 2017) whilst also addressing rural

poverty (Geall et al. 2017). The PRC therefore made ambitious international commitments to the Paris Agreement in the run-up to COP21 (Aldy et al. 2016), with its intended nationally-determined contribution (INDC) committed to peak its emissions and increase its share of non-fossil fuels in primary energy consumption to around 20 percent by 2030 or earlier. Through its approaches to fostering 'ecological civilisation' (Geall and Ely, in press), the government of China is attempting to address environmental challenges whilst also rebalancing the country's geographic and societal inequalities, and building an innovation-based economy. At the same time, the country's scale, its unique socio-political context, with a comparatively strong state and comparatively rapid and sustained economic growth, have allowed a unique set of approaches to driving systemic change. This has translated to an outstanding development of installed capacity of renewable energy, up to 564 GW in China including hydro by the end of 2016 according to REN21 2017, and growing capabilities in low carbon innovation in sectors, such as mobilities, agriculture and buildings. Together, these supply-side phenomena have contributed to what might be referred to as 'low carbon transitions with Chinese characteristics'. They have been of central interest to both policy makers and transitions scholars.

China's thirteenth five-year plan redoubles its focus on innovation and the supply side, including through frontier science and research in strategic areas, but also extending to 'mass innovation' and 'mass entrepreneurship' - a recognition of the role of small and medium enterprises and start-ups, especially in the digital realm (Keane and Chen 2017). The thirteenth plan also maintains its focus on ambitious climate targets and 'green industries,' but with a greater recognition of market demand as a driver (Geall 2017), suggesting a maturing of the view associated with a supply-driven transition. In parallel with these top-down pronouncements and government-led actions, the emergent contributions of China's firms, communities and citizens in different regions of China represent a vital aspect of systemic change, but remain largely unexplored in the international transitions literature.

This collection tries to look outside the conventional understanding of 'low carbon transitions with Chinese characteristics' to explore emerging phenomena that are contributing to a greater appreciation of socio-technical change in different parts of the country, and the role that China's unique socio-political context has played in enabling and constraining system transitions.

2. From Low Carbon Technologies to Socio-technical Change

Low carbon innovation in China has been the subject of scholarly research in the West for over a decade (Watson et al. 2000; Sims-Gallagher 2006; Wang and Watson 2009), but with relatively little theoretical application of transitions frameworks. Most of the literature that has so far investigated these issues emphasizes the 'supply side' of the "sustainability-oriented innovation system" (a term coined by Altenburg and Pegels 2012) and growing technological capabilities in China's renewable energy sector (Altenburg 2015; Lema and Lema 2012; Schmitz and Altenburg 2015).

Such work has focussed on China's 'planned' innovation system, including R&D policies and efforts to link R&D with firm actors (Lema and Lema 2012). Studies of public policies outside the R&D realm, for example strong state investment in the creation of demand (see, e.g., Mazzucato (2013) for wind, and Fischer (2012) for solar PV) and various other aspects

of the policy mix (see the study by Lacerda and Van den Bergh (2014) on wind)[1] have further improved our understanding of the shift towards renewable energy systems. Attending to governance approaches underlying some of these policies, Fischer and Chen (2011) have investigated energy intensity targets under China's 12th Five Year Plan and looked at the multi-level responsibility of national and provincial governments.

Whilst firm strategies (e.g. vertical integration, acquisitions - see Lema and Lema 2012) have been investigated for their role in positioning China as a lead market in renewables (Walz and Köhler 2014), there has been less focus on diverging technological trajectories. The government's focus on generating indigenous intellectual property in these areas aims to place China in a position for "corner overtaking" (Geall and Ely 2015) – a term coined by science minister and former Audi executive Wan Gang to describe leap-frogging in the electric vehicle sector (Tyfield et al. 2014). Diverging from trajectories followed by Western auto firms, rather than following the regimes associated with the internal combustion engine, raises the promise of socio-technical transition towards cleaner mobility regimes (Tyfield 2014).

Interrogating whether China is indeed leading or following, Pan et al.'s paper in this issue draws on patent analysis methods, which have previously been neglected in transitions research, to illuminate firm strategy in China's wind power sector. Providing novel and fascinating insights into the approaches to acquiring and accumulating technological capabilities, this paper points primarily to a 'following strategy' amongst Chinese firms and responds to earlier questions around the possibility of divergence of trajectories in sustainability-oriented innovation systems (Altenburg and Pegels 2012). At least in the wind sector, they find this to be unlikely.

Going beyond technology-focused approaches, however, this special section explores emerging phenomena in China and their implications for the complex, multiple and systemic processes involved in sustainability transitions (Elzen et al. 2004; Smith et al. 2010). This responds to calls in recent work on low carbon innovation in China (Tyfield et al. 2015) that has pointed to the need for increased attention to politics and practices. In moving beyond conventional accounts of 'low carbon transitions with Chinese characteristics', therefore, this special section will pay particular attention to three previously neglected themes: firstly, learning from demand successes, secondly the role of users and citizens in China's low carbon transition and thirdly transition politics and policy in the Chinese context.

3. Learning from and Regulating Demand Successes

As discussed above, the Chinese government has built strong capabilities by supporting the development of specific technologies associated with large firms working in strategic emerging industries such as renewables or electric mobility. Beyond high-tech innovation in large firms, some of the greatest successes in terms of the diffusion of low-carbon innovation have emerged from small firms working in lower-tech areas that respond to consumer demand and better integrate with current social practices. Technologies such as solar water

[1] Lacerda and Van den Bergh (2014) mention feed-in tariffs, auction or tendering systems, concessionary finance through government supported agencies, concessions on import duty, renewable energy portfolio standard or purchase obligation, federal or state-level targets (binding or indicative) for electricity generation, and projects permitting process and priority access to the grid.

heaters (Urban et al. 2014) and electric two-wheelers (Tyfield 2014) exemplify these forms of disruptive innovation.

Zuev et al.'s paper in this issue investigates China's emerging transition to electric mobility. In contrast to other studies, which have focussed on electric carproducers such as BYD, Zuev et al. focus on the potential contribution of electric two-wheelers (E2Ws) to low-carbon trajectories of urban mobility. Electric car manufacturers have been identified by the Chinese government as potential 'indigenous innovation' rivals for incumbent auto-manufacturers (e.g. Toyota) or emerging competitors (e.g. Tesla), however electric cars have seen sluggish rates of adoption, despite state support. E2Ws, in contrast, have been an unquestionable demand success in the absence of equivalent state support. Zuev et al. use this uniquely Chinese case to explore the role of power and politics in socio-technical transitions, providing a useful addition to the largely Western context in which these issues have so far been addressed (Avelino et al. 2016). They adopt China-specific concepts such as *suzhi* (quality, referring to people) to explain the politics behind national and local government attempts to regulate the E2Ws. Their concept of 'civilisational government' provides a marked contrast to earlier analyses (e.g. Ruan et al. 2014) by recognising the Chinese government's authority to determine what is 'quality' or 'civilization', and thus the direction of transitions that directly involve its citizenry. This links to the next theme addressed in this special section.

4. Users and Citizens in China's Low Carbon Transitions

Within the European transitions studies, there has recently been an increasing acknowledgement of the role of technology users in shaping routines and enacting system change (Schot et al. 2016; Fox 2018). Schot et al.'s (2016) typology represents an improvement on the treatment of users within the multi-level perspective on socio-technical transitions (Geels 2002), which defines socio-technical regimes as being made up of seven dimensions, among these, "culture, symbolic meaning" and "markets, user preferences". Within Schot et al.'s (2016, page 4) typology, user-citizens "engage in regime-shift politics, lobbying for a particular niche and against the regime (or other niches)", however such direct citizen action is heavily constrained in China's socio-political context. "User-consumers not only buy products but also embed them in their daily practices, thereby defining their lifestyles" (ibid., page 5). Two of the papers in this special section illuminate these dynamics in the Chinese context, through examining the demand for electric vehicles and its link to user practices and identities (Zuev et al., this issue) to preferences for organic and non-GM food (Geall and Ely, this issue).

Zuev et al. provide a detailed analysis of the everyday practices (and everyday politics) surrounding electric two wheelers (E2Ws) use in Chinese cities. Drawing on focus groups to explore gender, and class dimensions, they provide a convincing argument for why E2Ws have been taken up in such great numbers, at least within certain social groups. Their discussion of civilizational government refers to the identity politics associated with some of these citizens' disruptive, 'uncivilised' practices. This raises questions about the direction of transitions in the Chinese context.

Geall and Ely's paper examines China's agri-food transitions, another key area of social and environmental concern in China, and one that is also being addressed through significant government investment in science-led innovation. Transgenic agriculture forms a key component of this dominant, 'top-down' approach (Ely et al. 2016). Criticising the existing

literature that has primarily looked at public perspectives using quantitative approaches, Geall and Ely point towards some of the apparent determinants of user consumers' preferences around transgenic and conventional/ organic foods, calling for qualitative research methods that might enable more nuanced and sophisticated understandings of the role of users (including through their agency as citizens) in current transitions. These question the governments' current approaches to public education and information, and point to deeper challenges of government legitimacy (resonating also with Dai's paper discussed in thenext section).

5. Transitions politics and policy in the Chinese context

Following criticism of earlier transitions frameworks for the lack of attention to politics and agency (Meadowcroft 2005), the social and political dimensions of such transitions have been investigated a great deal in Europe (Kern 2011; Verhees et al. 2013). However, little of the international literature has dealt in detail with these dimensions in China. The country's unique history, as well as its political system – variously described as "hard authoritarianism", "fragmented authoritarianism" or "consultative authoritarianism" (Geall and Ely, this issue) - demands that such analysis is conducted with an appreciation of its socio-political context, most notably, the central role of the state.

Against this background, Dai's paper in this issue adopts technology legitimacy as a new perspective on low-carbon innovation governance, and investigates effectiveness of legitimacy gaining tools. China's centralized policy structure has advantages in promoting technology research and development, yet, it has not been able to guarantee technology legitimacy, as demonstrated by the many nuclear projects encountering social opposition that were forced to be postponed or cancelled (He et al. 2013). Besides traditional tools of technological education and economic benefit sharing, new methods are being designed so that nuclear technology could be integrated into local cultural and social norms. The challenge remains how to ensure technology legitimacy during the transition process in the long-run. Particularly, it requires further discussion of what should be the proper scope of the "public", and how to deal with changing public perceptions through time.

Another characteristic of China's unique socio-political system is the relationship between the central and local governments and the role of experimentation - a long-term focus of China studies, with recent work taking this tradition forward in examining the role of local government innovation in various sectors (Husain 2015). Following local experimentation, central government action is often taken to draw lessons together in a unified approach across the country. For example, China initiated a pilot program of River Leaders in the polluted Tai Lake region, in which prefecture-level cadres were assigned the role of river leader and their administrative assessment were tightly bound with the water quality of the watershed they were assigned. This new governance mechanism, after eight years of experiments, was formally promoted to the whole country in 2016 (Chien & Hong 2018).

Some authors have begun to look at the political economy (Schmitz 2016) of policies for low carbon development in China at national or provincial levels, a theme touched upon by Zuev et al. in this issue. The paper of Shen and Wang's in this issue extends this aspect of the literature by providing an in-depth analysis of China's experimentation with a national carbon trading scheme – announced at the COP21 in Paris with the promise of being the largest such scheme in the world by 2017. Emerging from a process through which provincial-level pilots use adaptive policy innovations that were envisaged to contribute to the design of the national

policy, this represents a classic case in which central-local dynamics are a key analytical consideration. The potential contribution of the Chinese national emissions trading system to the country's low carbon transition is immense, but Shen and Wang's paper also points towards potential challenges to the legitimacy of a national scheme – a context-specific question in which it is unclear whether traditional concepts from the transitions literature (and an exploration of the politics of transitions in the West) have much to contribute. Shen and Wang demonstrate how, in the case of a Chinese emissions trading system, the unified national plan is illusive. It is an open question whether this marks a move towards allowing more plurality across the country and a diversity of policy approaches at provincial level, or whether this is a phase, pending a more top-down move by the National Development and Reform Commission to create a single market.

6. Implications for Transitions Studies and Low Carbon Innovation in China

Taken together, the articles in this collection describe emerging phenomena within the changing governance context of China's innovation system, and presents insights for transitions scholars and Chinese and other government policy makers alike.

In line with other studies, the strengths of China's 'planned' innovation system in building technological capabilities, particular in the nuclear (Dai, this issue), wind energy (Pan et al., this issue) and agricultural biotechnology (Geall & Ely, this issue) fields, is clear. In comparison to previous papers that emphasise this planned innovation system focussing on government R&D and the supply side with relatively less attention to other aspects, this collection highlights the importance of the demand side, of citizen perceptions and practices, and of local in addition to national governments as key policy actors. The phenomena studied here, to a greater extent than in the previous literature, illustrate a broader vision of an 'emergent' rather than planned innovation system recognising 'bottom-up' contributions to wider socio-technical change. Whilst resonating strongly with findings from transitions studies in the West (Elzen et al. 2004; Smith et al. 2010), this is relatively new territory for the Chinese governance context. The implication – in contrast to oversimplified notions of Chinese authoritarian approaches - is that policy makers have less of a role in planning, and more in providing space for experimentation (as advocated in niche-based approaches) than previously recognised. This represents a previously neglected insight deserving of more focussed attention by the transitions community. Recent years have seen an increasing number of relevant examples, such as shared bikes and cars, in China. Providing a suitable environment to enable these niches to grow, yet addressing possible market failures, is a huge challenge for the Chinese government, which is still in the relatively early stages of learning how to regulate the market. These represent vital areas for future research.

Whilst there has traditionally been less focus on public perceptions or engagement within China's 'planned' innovation system, several of the papers illustrate that this should increasingly be a government concern, particularly in controversial technological areas such as nuclear. US Studies of nuclear power back to the 1970s (Fischoff 1995) discussed how enhancing policy legitimacy through various forms of public engagement has been a challenge in Western democratic societies, and more recent work has explored the potential role of more participatory innovation policy processes for renewable energy (Reichardt et al. 2017). Other work in the Chinese context puts forward a view of public engagement as co-optation (Zhou and Dai, 2017), suggesting that surveys are used as a form of symbolic inclusion of the public, making it more likely for them accept the proposals. It is an open

question (which varies across different sectors and regions) whether China is moving towards enhanced public engagement as a democratic process or as co-optation. Given the trade-offs, complexities and cultural considerations associated with these policy challenges, the normative dimensions of this question are far from clear. Hence, they represent an important area for future research.

In summary, the papers in this special section present insights for the wider transitions research community and for policy makers in China and beyond. They have applied concepts and tools developed in the literature that have derived primarily from empirical studies in Western countries to the very different socio-political context in China, and illuminated emerging phenomena in China in new ways. At the same time these phenomena raise new questions for transition research, illustrating the value of testing analytical frameworks in different contexts and the necessity of critical reflection around their applicability. Lastly, the collection also points to the positive opportunities for ongoing international collaboration (in research and policy) around the shared challenge of decarbonisation in the post-Paris era.

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